PATENT SPECIFICATION

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(54) HOLLOW FIBER SEPARATORY DEVICE

(71) We, THE DOW CHEMICAL COMPANY, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of Midland, County of Midland, State of Michigan, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to separatory devices and, in particular, to hollow fiber separatory devices.

Hollow fiber separatory devices are well known in the prior art. A diversity of hollow fiber membranes having properties of being selectively permeable to different components of fluid mixtures, i.e. liquid or gaseous mediums when treated under hyperatmospheric pressures, and device configurations employing the same are also well known. Generally, these devices have the ends of the hollow fibers imbedded in a sealant which comprises what is commonly referred to as a "tubesheet". The tubesheet, which effects a seal around the exterior of each fiber end, separates the region communicating with the exterior of the fibers from the region on the opposite side of the tubesheet which is in communicating relationship with the hollow interiors, or lumens, of the fibers.

These separatory devices are used in a wide range of separatory procedures such as, for example, reverse osmosis or ultrafiltration of saline or brackish water to produce potable water, gas separation or oxygenation-type procedures. In many of these procedures, relatively high pressures, e.g. from 400 to 1600 p.s.i., are employed to accomplish the separation desired. However, subjecting the tubesheets of separatory devices to high pressure differentials for extended periods of time during operation is known to cause deformation of the tubesheets leading to breakdowns due to attenuation and eventual rupture of fibers or leakage due to the development of cracks in the tubesheets unless the same are mechanically supported.

One solution to this problem is disclosed in U.S. Patent No. 3,442,008, wherein a perforated metal plate is provided adjacent to the low-pressure face of the tubesheet member. The use of this perforated metal plate provides support for the tubesheet and also provides for greater efficiency and economy due to lower cost and requirement for resin in the tubesheet and better fiber utilization since the tubesheet can be significantly thinner than it would be without the perforated metal plate.

As noted in U.S. Patent No. 3,702,658, a perforated metal plate reduces the efficiency of a separatory device by blocking the openings of a significant number of fibers. It was also found to be impractical to form the plate with a greater number of perforations sufficiently close together to avoid the blockage of the fiber openings. U.S. Patent No. 3,702,658 teaches the use of an inert, porous, non-compressible support member adjacent the lower pressure face of the tubesheet such that the pressure differential applied to the tubesheet during operation of the device is transmitted through the support member to the apparatus. The support member is taught to eliminate creep, cold flow and plastic deformation of the tubesheet and to make it possible to effect significant economic savings since the tubesheet thickness can be reduced to thereby cause a reduction in the pressure drop in the fibers or capillaries employed.

However, the porous support members of U.S. Patent No. 3,702,658, which can be formed from a bonded sand, ceramic or powdered metal member, or a woven wire screen or sieve, also suffer disadvantages in that some loss of productivity is experienced. In this respect, the effective width of the surface segments of the support member is taught as being from about 2 to about 50 times the average inside diameter of the hollow fibers or capillaries employed in the device. Hence, in all instances, the smallest dimension of the surface segments will be at least about twice as large as the inside

diameter of the fibers employed, thereby completely blocking the open ends of some of the fibers in the device. This blockage, which would become more severe as larger effective surface segments are employed with the same size fiber, accounts for a loss in productivity, especially at higher operating pressures.

According to the present invention there is provided a hollow fiber separatory device wherein the fibers extend through a tubesheet and have open ends thereof terminating at a lower pressure face of the tubesheet, which device comprises a porous support member having interconnected porosity and comprising an inert, non-compressible member for reducing deformation of the tubesheet and for maintaining the relative position thereof within the device when a pressure differential is applied to the tubesheet, the support member being positioned adjacent the lower pressure face of the tubesheet and being adapted to transmit to the separatory device a force corresponding to the pressure differential, the support member having surface segments in contact with the tubesheet face, wherein the average effective width of the segments is less than twice the average inside diameter of the hollow fibers, and the total area of the surface segments comprises from 15 to 70 percent of the total surface area of the support member.

The use of a support member makes it possible to improve the economics of a separatory device since the tubesheet thickness can be reduced, thereby also producing a reduction in pressure drop in the fibers embedded in the tubesheet. Moreover, the selection of materials used for tubesheet construction can be broadened. The support member can also be relatively thin as compared with the thickness of the tubesheet which is being supported, thereby reducing the need to alter many existing separatory devices to accommodate the same. The present invention further offers particular economic advantages in that productivity, e.g. the output of potable water in a desalination separatory device, for example, per unit of time, is improved with the tubesheet support member hereinafter described in detail.

A more complete understanding of the manner in which the porous support member may be applied to known separatory devices, is afforded by reference to the drawings which illustrate preferred embodiments of the present invention.

Figure 1 is a longitudinal cross-sectional view of one embodiment of a "single-ended" separatory device of this invention.

Figure 2 is a longitudnial cross-sectional view of another embodiment of a "double-ended" separatory device wherein two supported tubesheets are positioned so that the low pressure faces thereof are opposed to each other.

Referring to Figure 1, there is shown a separatory device commonly known as a single-ended type device, i.e., a device in which the open ends of the fibers all terminate in a single tubesheet which is positioned in an open end in the casing which accommodates the fiber/tubesheet assembly. The separatory device 10 comprises a casing or shell 11 having an open end 11a and a closed end 11b and containing a plurality of hollow fibers 12 the ends of which are potted in tubesheet member 13. The hollow fibers are looped to form a U-shaped bundle of fibers (not illustrated). The fibers are open at their ends and are flush with an outer face 13a of the tubesheet 13 to permit communication between the interior of the hollow fibers 12 and a permeate collection chamber 14. A porous support member 15 is positioned in the chamber 14 and provides a bearing or support surface 15a which is flush with the outer face 13a of tubesheet 13. An end closure member 21, which supports the support member 15, is retained within casing 11 by an annular retaining ring 22 which is positioned in a groove 23 provided in casing 11. O-rings 24 and 25 are positioned in grooves 24a and 25a provided on the circumferential surface of tubesheet 13 and end closure 21 to seal the tubesheet 13 and end closure 21 to casing 11. Fluid at a high pressure is introduced into a perforated inlet tube 16 and flows radially outwardly through openings 18 across the fibers 12. Inlet tube 16 is generally centrally located within the bundle of hollow fibers and has one end 16a embedded in the tubesheet 13 in a fluid-tight relationship therewith so that feed water does not enter the permeate collection chamber 14. All of the reject fluid or concentrate (fluid remaining after the permeate has passed through the fiber walls) exits from the casing 11 through outlet 19. The permeate, i.e. the portion of the fluid which passes through the walls of the hollow fibers 12, is carried through the interiors of the fibers 12 through tubesheet 13 and out of the open fiber ends and percolates through the porous support member 15 and is withdrawn by known collecting means (not illustrated) through permeate outlet conduit 20.

It should be noted that a satisfactory support of the tubesheet 13 can be obtained by inserting the support member 15 (which can be of the same size or of a smaller size as the tubesheet) between the end closure 21 and tubesheet face 13a to be supported, thus completely filling the space or chamber defined by said end closure, tubesheet and casing with the support member. When

the device is arranged in this fashion, the end closure can be provided with water collection means, e.g. channels routed out or grooves provided on the surface thereof and with the grooved surface of the end closure in contact with the support member to provide for ready flow of the permeate from the support member to the permeate outlet conduit 20 of the device. The surface of the support member 15 which is adjacent to the end closure can, where the support member is of suitable thickness, itself be grooved or channeled to provide for the flow of permeate to the permeate outlet conduit. Alternatively, a wire screen comprising one or more wire screens of the same or different mesh, or a drilled or perforated metal plate can be placed between the end closure 21 and the support member 15 to provide ready egress of the permeate percolating through the pores of the support member to the permeate outlet conduit.

The described support member embodiment of the invention can also be employed in double-ended separatory devices, i.e. those having the ends of each fiber length terminating in opposing, spaced-apart tubesheet members. Thus, in a preferred embodiment, the improved support members of the present invention are utilized in so-called double-ended devices with a centrally-located perforated feed or exit tube.

In another embodiment, separatory devices may be employed wherein two tubesheets are in close proximity to each other and the permeate exiting from the fibers embedded in the tubesheets is collected by a common collection means. Such device is illustrated in Figure 2 wherein two tubesheets are each supported by a separate support member and a spacing means positioned therebetween so that fluid permeating through the hollow fibers percolates through the support members and is withdrawn from a common permeate chamber and permeate outlet. The device is pressure balanced, i.e. the pressures exerted on the high pressure sides of the tubesheets are transmitted to each other through the support members, and not directly to the separatory device as in the embodiment of Figure 1, thus effectively balancing the pressures exerted on the tubesheets. While it is feasible to support the adjacent tubesheets with a single support member, the support member would have to be of greater thickness in order to provide for adequate throughflow of permeate and egress from the device. Alternatively, slots or holes can be provided in the support member to enhance removal of the permeate from the common support member.

In Figure 2 is illustrated a separatory device 26 comprising a casing 27 having two opposed open ends 26a. A plurality of hollow fibers 28, 28′ which form fiber bundles 28a and 28b are positioned in the casing. The fibers in each bundle are U-shaped (not illustrated) and have their open ends embedded in tubesheets 29 and 29′ such that the open ends are flush with outer pressure faces 29a formed by the tubesheets 29 and 29′. The outer faces of the tubesheets 29 and 29′ are opposed to each other and form a permeate collection chamber 31 therebetween. Wall members 30 and 30′ are optionally provided to support the looped ends (not illustrated) of the fibers. Porous support members 32 and 32′ provide bearing or support surfaces which are flush and in engagement with the outer faces 29a of tubesheets 29 and 29′ and occupy a portion of permeate chamber 31. Perforated permeate collector plates 33 and 33′ are optionally positioned within chamber 31 and are placed adjacent to porous support members 32 and 32′. The collector plates 33, 33′ are opposed to each other and held in a relatively spaced relationship against support members 32 and 32′ by means of stay rods, some of which are depicted at 34. End closure members 35 and 35′ are retained inside the casing 27 by retaining rings 36 and 36′ which fit into grooves 37 and 37′ provided in the casing 27. O-rings 38, 38′ and 39, 39′ seal the tubesheets 29 and 29′ and the end closures 35 and 35′ to the casing 27. Fluid at high pressure is introduced into each of the perforated inlet conduits 40, 40′ as illustrated by the arrows. The fluid preferably enters the conduits at the same or substantially the same pressure to place the tubesheets under a pressure balanced condition. The conduits pass through the end closure members 35 and 35′ and wall members 30 and 30′ in a fluid-tight relationship therewith. Fluid flows through openings 42, 42′ in the outlet conduit radially outwardly through the fiber bundles. The openings 42, 42′ may be in the form of slots positioned at spaced intervals along the lengths of the conduits which extend between the wall members 30, 30′ and tubesheets 29, 29′. The conduits 40 and 40′ are centrally located within the fiber bundles and have one closed end thereof embedded in the tubesheets 29 and 29′ in a fluid-tight relationship therewith so that the feed fluid does not mix with permeate in chamber 31. All of the reject or concentrate flows along a space 27a provided between the tube bundles and an inner surface of the casing 27 and exits from the casing by way of outlet conduits 43 and 43′.

The fluid which permeates through the fiber walls is carried along the interiors of the hollow fibers 28 and 28′, through respective tubesheets 29 and 29′, and out of the open ends of the fibers where it percolates through the porous support members

32 and 32′ and collector plates 33 and 33′ into chamber 31, and is withdrawn from the separatory device 26 through a permeate outlet conduit or conduits 44 and 45 which are in communication with the chamber 31.

While stay rods are depicted in Figure 2 as maintaining the collector plates 33, 33′ rigidly against the support members 32, 32′, thereby cancelling out, e.g. "balancing", the pressures exerted on the high pressure sides of the tubesheets, other means, such as a perforated cylindrical disc or spacer member can similarly be employed.

In the embodiments illustrated in the drawings, the fiber bundles consist of essentially parallel fiber lengths which are flattened, continuous loops. However, a fiber bundle may also consist of fiber lengths arrayed in any manner which is regular or non-random, i.e. which will permit space-efficient fiber packing, essentially uniform fluid feed distribution throughout the bundle, and equally low resistance to permeate flow through adjacent fiber lumens. Thus, now well known, arrangements, in which the fibers are disposed in successive, criss-crossed layers of spaced spirals around a central tube or fibers which are generally parallel to the longitudinal axis of the tube but which cross each other at a shallow angle, may be employed. Additionally, the fiber bundle may include means, such as a sleeve or fabric wrap, for constraining the fibers in the bundle and/or for improving the uniformity of distribution of the feed fluid between the fibers.

As a general rule, the tubesheet member will be built up by applying a suitable, flowable potting material (preferably a curable resinous composition) at appropriate rates at the center and ends of the bundle as it is being formed, and then solidifying the resulting bodies in place. Details of this procedure and various materials which can be employed are well known to those skilled in the art.

The perforated inlet conduit can be made of any suitable material but strong, lightweight materials are preferred. The concentrate outlet conduit is pressured from the outside in and hence does not have to be as strong as the tube: commercial polyvinylidene chloride-based (Saran-type) pipe extrusions are quite satisfactory for this use. Saran is a registered trade mark. Stronger materials such as chlorinated polyvinylchloride and filament reinforced epoxies or polyesters are suitable tube and conduit materials. The casing is formed by known procedures and from known materials with fiberglass which is preferably wound upon a metal casing support being a preferred casing material.

A variety of materials (and methods) are known to be suitable for the preparation of hollow fibers having the requisite strength, chemical resistance and permeability properties for a diversity of separatory processes. Similarly, a variety of potting materials and several different methods for forming tubesheets or wall members from such materials are well known and the present invention may be practiced with virtually any appropriate combination of fiber and tubesheet materials. Likewise, the spacing and size of slots or perforations in the inlet conduit will depend upon the particular operation and will be apparent to those skilled in the art. Additionally, while the embodiments are described with reference to treatment of liquids, gas separation procedures can similarly be carried out, the term "fluid" being meant to include liquids as well as gases.

The porous support member of this invention is employed to reduce cold flow and plastic deformation of tubesheets in separatory devices used in high-pressure separatory processes. The support member is porous, and can be formed of any material which is non-compressible and essentially inert or non-reactive with respect to gases or liquids which are contacted in a particular treating operation.

Deformation of the tubesheet is reduced and the relative position thereof within the device is maintained when a pressure differential is applied to the tubesheet.

Packed or bonded sand, ceramic, or powdered metals or metals in the form of woven wire screens or sieves have been used as support members. The effective widths of the surface segments of such support members (which can be rounded or completely flat) which are in contact with the tubesheet face to support the same are taught as being from a multiple of 2 to 50 times (preferably from 10 to 30 times) the average inside diameter of the fiber employed. The use of such support members has, however, been found to be detrimental to the productivity of separatory devices, apparently due to the blockage of some open fiber ends by the surface segments of the support.

It has been discovered, however, that support members of the present invention adequately support the tubesheet, e.g. prevent small scale creep, cold flow and plastic deformation of the tubesheet, at higher pressures required for most separation operations, without significantly impairing the productivity of the separatory device by restricting flow from the open fibers. The improvement in the support member of the present invention is obtained in that the average effective width of the surface

segments of the support member, i.e. the smallest width of the surface segment which is in contact with the tubesheet face, is less than twice the average inside diameter of the fibers. Preferably, the average width of the segments are the same or less than the average inner diameter of the fibers employed. In a highly preferred embodiment, the average width of the surface segments of the support member is less than the average inner diameter of the hollow fibers employed. The support member is employed in operations where pressures of at least 200, and preferably at least 400 psi are utilized.

The support members of this invention can comprise materials such as microscopic, intertwined and sinter-bonded metal fibers or porous metal structures, which can be in the shape of, for example, discs or sheets, or which can be adapted to assume the particular configuration of the tubesheet face to be supported. The support members can also be characterized as being relatively thin in comparison with the thickness of the tubesheet to be supported and when compared with the thickness of known prior art support members. In this respect, tubesheet members in typical reverse osmosis devices are from 2 to 4 inches thick while known support members are at least one inch thick. However, the support members of the present invention can be less than about one-half inch and can even be as thin as about twenty-five thousandths of an inch.

The support members are further characterized as having interconnected porosity, e.g. pores which are connected by openings so that a fluid can flow through the material with substantially the same resistance to flow in all directions. The total area occupied by the surface segments of the support members can range from 15 to 70 percent of the total support member surface area and preferably is from 15 to 25 percent. The fraction of the surface area of the support members represented by the pores or interconnected openings between the surface segments can be from 30 to 85 percent, preferably from 75 to 85 percent, thereof. In general, a higher percent of porosity is desired since, as will be recognized by those skilled in the art, this will minimize the complexity of the permeate water collection means and reduce the tendency of such collection means to diminish the strength of the support member.

In one embodiment of the invention, preferred materials which can be employed as support members include microscopic, intertwined and sinter-bonded metal fibers such as stainless steel fiber filter media (sold under the trade name Dynalloy (registered trade mark), available from Fluid Dynamics, a Division of Brunwick Corp., Cedar Knolls, New Jersey, U.S.A.). These filter media are available in many size ranges such as from a grade having wire filaments of about 4 microns in diameter and pore openings of about 1 micron and an average overall porosity of about 39 percent (surface porosity being considered, in the present invention, to be the same or approximately the same as the overall average porosity of the support member) to a grade having wire filaments of about 25 microns in diameter, mean pore openings of about 46 microns and an average porosity of about 85 percent. The smallest or effective average width of the wire filaments (the length of which varies) at the surface of the filter media which is used as a support member in contact with the tubesheet face would thus range from 4 to 25 microns where the wire filaments are essentially flat. If the filaments are rounded, the average effective width would, of course, be somewhat less. Hence, with hollow fibers having an average inside diameter of about 25 microns, this particular filter media used for the support members would have average effective widths less than or equal to the average inside diameter of the fibers while, in those fibers haing average inside diameters of about 90 microns, the effective width of the surface segments would be less than the average inside diameters of the fibers. Other support members of this type employing larger size surface segments can, of course, be utilized so long as the effective width of the surface segments is less than about twice the average inside diameter of the fiber being employed.

In another embodiment, porous bonded metal structures can be employed. Structures, such as are available from Mott Metallurgical Corporation, Farmington Industrial Park, Farmington, Connecticut, U.S.A., and having nominal retention properties of from 0·5 to 40·0 microns are preferred. In one such structure having, for example, a grade rating of 5·0 micron retention, the surface segments average about 44 microns in diameter, the surface pore openings are less than about 5·0 microns in diameter and the average porosity is about 39 percent. In the structure having a nominal retention rating of 40·0 microns, the surface segments thereof range from 144 to 300 microns in diameter with a mean diameter of about 177 microns, the surface pore openings are less than about 40 microns and the average porosity is about 51 percent of the total surface area. The smallest or effective surface segment width, in the illustrations given, which would thus be in contact with a tubesheet face would thus be an average of about 44 and about

177 microns, respectively, or less where such segments are more elongated than spherical, or more rounded than flat. Thus, for example, where fibers having average inside diameters of about 25 microns are employed, the surface segments of the support member having an effective average width of less than about 44 microns would be less than about twice the average inside diameter of the fibers. Where the fiber has a typical inside average diameter of about 90 microns, the support member wherein the surface segments are an average of about 44 microns would always be less than the fiber average inner diameter, whereas the support member wherein the surface segments are an average of about 177 microns would also be less than about twice the average inside diameter of the fiber employed.

The preferred support members described above can, of course, all be utilized with hollow fibers having inside diameters greater than 90 microns. Similarly, other support members having larger surface segment widths can also be utilized and/or fabricated for use as support members in the described invention. The support member material may be of any suitable material inert to the permeate fluid and may include, for example, metals such as stainless steel, copper or other corrosion resistant alloys, or ceramics.

In a single-ended separatory device of the present invention, the support member is adjacent to and in uniform contact with the lower-pressure face of the tubesheet at which the open ended fibers terminate. The support member supports the tubesheet and transmits, through other parts of the separatory device, the pressure differential applied to the tubesheet. Plastic deformation of the tubesheet is reduced because of the applied pressure differential.

Tests were conducted employing a commercially available reverse osmosis separatory device of the type generally depicted in Figure 1 of the drawings and having a support member as described in U.S. Patent No. 3,702,658. The tubesheet support member of the separatory device was interchanged with a porous support member of the present invention and productivity of the separatory device at pressures typically employed for reverse osmosis treatment of saline water, i.e. about 400 psi, were then compared. In the commercial device, rated at a productivity of about 4,200 gallons per day at 400 psi, the hollow fibers were about 30 to 35 microns in average inner diameter and the porous support member was about 1 inch thick and had surface segments which appeared to average about 450 microns in width and about 900 microns in length. The support member of the present invention was an intertwined, sinter-bonded metal fiber disc (Dynalloy filter media grade #X13, mean filter porosity of about 46 microns) about twenty-five thousandths of an inch in thickness, having surface segments of about 25 microns in effective width and a porosity of about 85 percent, said support member being backed by a wire screen through which the pressure differential exerted on the tubesheet was transmitted to the device. The device was operated with the support member of the present invention for one hour at 400 psi, then removed and replaced with the porous tubesheet used in the commercial device, which was then operated for one hour at 400 psi. Such support member was then again replaced with the support member of the present invention and then operated for a one hour period at 400 psi. At the conclusion of each operating period, the intrinsic productivity of the device was measured to compare the effect of the support member on productivity.

As a result of such operations, it was found that the intrinsic productivity of the device operated with the support member of the present invention (having surface segments of average width less than the average inner diameter of the fibers) was about 9 to 10 percent greater than when the device was operated with the known tubesheet support (wherein the surface segment average width was greater than the average inner diameter of the hollow fibers). With the device utilized, a gain of about 400 gallons per day was realized; this gain in productivity over the known tubesheet support member (or deterrence of productivity loss) is economically significant, especially with larger devices having productivity ratings as high as about 20,000 gallons per day.

In other operations, it is found that the support members of the present invention offer support against tubesheet deformation, while producing little, if any, retarding affect on device productivity.

WHAT WE CLAIM IS:—

1. A hollow fiber separatory device wherein the fibers extend through a tubesheet and have open ends thereof terminating at a lower pressure face of the tubesheet which device comprises a porous support member having interconnected porosity and comprising an inert, non-compressible member for reducing deformation of the tubesheet and for maintaining the relative position thereof within the device when a pressure differential is applied to the tubesheet, the support member being positioned adjacent the lower pressure face of the tubesheet and being adapted to transmit to the separatory device a force corresponding to

the pressure differential, the support member having surface segments in contact with the tubesheet face, wherein the average effective width of the segments is less than twice the average inside diameter of the hollow fibers, and the total area of the surface segments comprises from 15 to 70 percent of the total surface area of the support member.

2. A device as claimed in claim 1 wherein the average width of the segments of the support member is equal to or less than the average inner diameter of the hollow fibers.

3. A device as claimed in claim 1 or claim 2 wherein the support member is made from a metal, powdered metal, an intertwined, sinter-bonded metal fiber structure, sand or ceramic.

4. A device as claimed in any one of the preceding claims wherein the total area of the surface segments of the support member comprises from 15 to 25 percent of the total surface area of the support member.

5. A device as claimed in any one of the preceding claims wherein the support member is in the form of a disc or sheet.

6. A device as claimed in any one of the preceding claims wherein the support member has a thickness of less than 0·5 inch.

7. A device as claimed in claim 1 substantially as hereinbefore described with reference to and as illustrated in Figure 1 of the accompanying drawings.

8. A hollow fiber separatory device comprising two hollow fiber tubesheet assemblies wherein the open ends of the fibers in each assembly terminate at the lower pressure face of the respective tubesheet, the tubesheets, being positioned in the device with the lower pressure faces thereof being opposed to each other so as to form a common permeate collection chamber within the device, an inert, porous, non-compressible support member having interconnected porosity positioned adjacent the lower pressure faces of each of the tubesheets and being adapted to transmit to the opposite tubesheet a force corresponding to the pressure differential, the support member having surface segments in contact with the tubesheet faces wherein the average effective width of the segments is less than twice the average inside diameter of the hollow fibers, and the total area of the surface segments comprising from 15 to 70 percent of the total surface area of the support member.

9. A device as claimed in claim 8 wherein a separate support member is adjacent the lower pressure face of each tubesheet.

10. A device as claimed in claim 8 or claim 9, wherein the average width of the segments is equal to or less than the average inner diameter of the hollow fibers.

11. A device as claimed in any one of claims 8 to 10, wherein the support member is made from a metal, powdered metal, an intertwined, sinter-bonded metal fiber structure, sand or ceramic.

12. A device as claimed in any one of claims 8 to 11 wherein the total area of the surface segments of the support member comprises from 15 to 25 percent of the total surface area of the support member.

13. A device as claimed in any one of claims 8 to 12 wherein the support member is in the form of a disc or sheet.

14. A device as claimed in any one of claims 8 to 13 wherein the support member has a thickness of less than 0·5 inch.

15. A device as claimed in claim 8 substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

16. A process for the production of potable water from brine or brackish water which process comprises passing the brine or brackish water through a hollow fiber separatory device as claimed in any one of the preceding claims and collecting the potable water therefrom.

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1566675 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

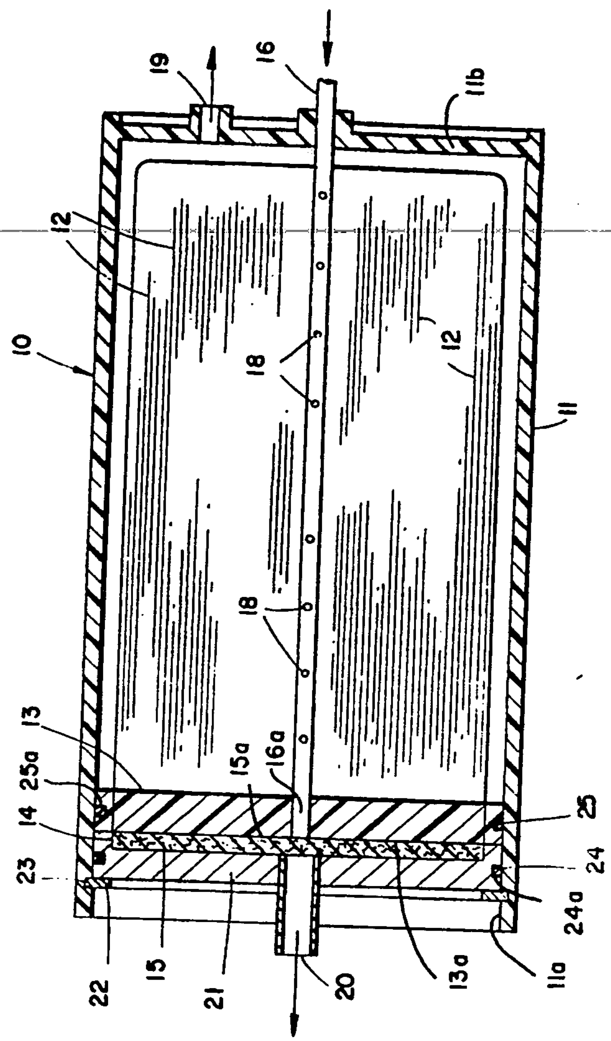

FIG_1

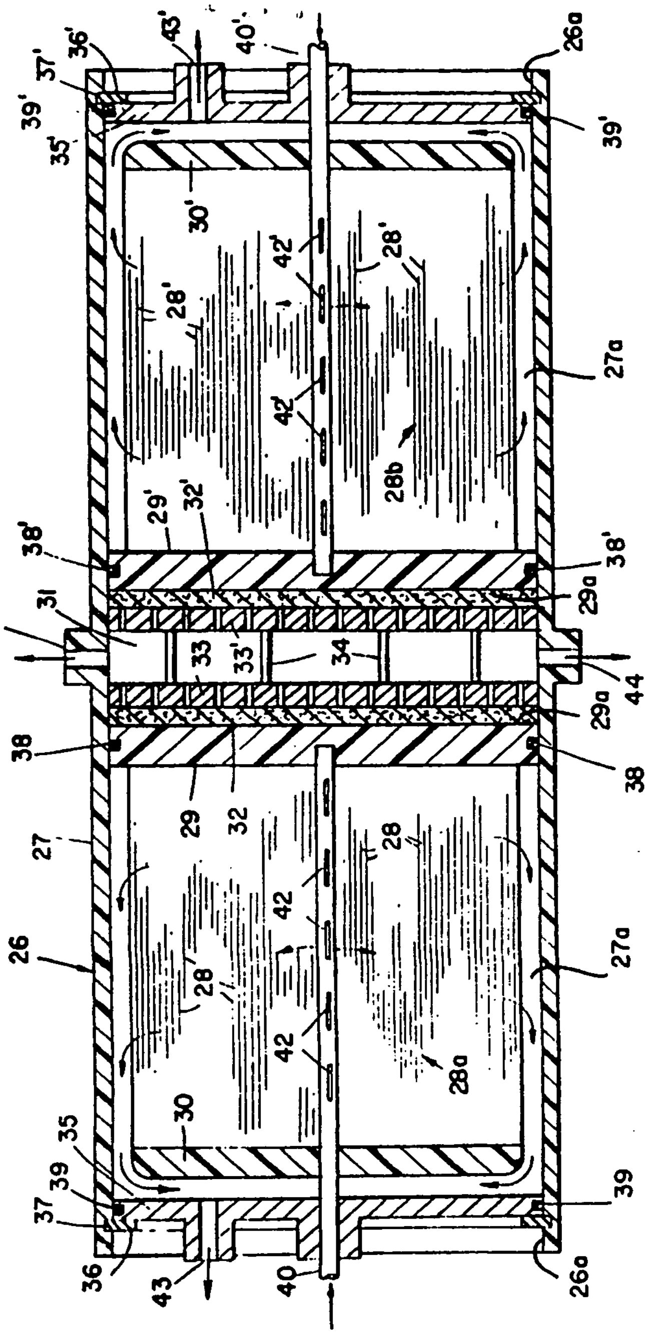
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FIG_2